

- Cohort studies looking at multiple health endpoints are beginning to evaluate health effects in populations of workers involved in the rescue and cleanup efforts.
- Studies are under way to investigate many different mental health outcomes including post-traumatic stress disorder, trauma to children, behavioral changes in adolescents, changes in therapy adherence in HIV/AIDS patients, impacts in particular NYC minority populations, and impacts in occupational groups involved in the cleanup and rescue efforts.
- While monitoring air quality is complete at the WTC site, NYSDEC will continue its routine ambient air monitoring at a number of nearby sites and at the sites around New York City, including a number of schools.

It is hoped that when they are completed, these studies will provide a more complete picture of actual health outcomes. This current report can only evaluate exposures based upon available monitoring data and results, and what these exposures could mean to human health. When the health studies are completed, it will be very useful for EPA to go back and reassess how well the evaluations in this report identified, or didn't identify, a human health concern. This retrospective look will help EPA and other health agencies to do a better job assessing health risks and outcomes in the future. In the meantime, EPA will continue to address potential health risks as needed. EPA will provide a more thorough report, looking at additional contaminants and conducting further evaluations as needed.

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**APPENDIX A - WORLD TRADE CENTER HEALTH EFFECTS SCREENING
CRITERIA FOR AMBIENT AIR DEVELOPED BY EPA'S REGION 2**

**Provided by: Mark Maddaloni
US EPA, Region 2**

World Trade Center Health Effects Screening Criteria for Ambient Air

Introduction

Extensive air quality monitoring data have been collected at and around the World Trade Center (WTC) site since 9/11/01. Table 1 (Screening Criteria) is intended to provide health protective screening values for data evaluation. Analysis has been performed on an extensive list of potentially WTC-related contaminants. Many of the chemicals screened have demonstrated a consistently low (i.e., below detection limits or trace amounts) trend. Consequently, the list of contaminants in Table 1 represents those chemicals that, because of their intrinsic toxicity and frequency/magnitude-of-detection, pose the greatest potential hazard from exposure. This selection process (i.e., a toxicity/concentration analysis), although qualitative, reflects the contaminant-of-concern identification process recommended in the Risk Assessment Guidance for Superfund. Table 1 may be expanded as additional data analysis becomes available. Two populations have been identified for assessment: response/demolition (i.e., WTC site) workers; and residents living in Lower Manhattan (e.g., Battery Park City, Tribeca and other residential locations close to Ground Zero). Included in the resident category are all other workers located in Lower Manhattan with the exception of WTC site workers.

Relevant Standards

The following paradigm has been employed to develop screening values. For each of the two identified receptor populations (i.e., site workers and residents), existing standards are utilized where appropriate. Occupational standards (i.e., OSHA PELs) are used for all site workers conducting response/demolition activities covered by OSHA. Monitoring data from demolition areas are compared to OSHA PELs. (For example, the OSHA PEL of 1 ppm for benzene is used to evaluate benzene air samples taken directly from within the plume on the debris pile.) Environmental standards (e.g., NAAQS, AHERA) are utilized to evaluate monitoring data from the site perimeter and beyond where residents or non-WTC site workers may be exposed. (For example, lead air monitoring data from perimeter stations outside of the immediate work zone are evaluated against the NAAQS of 1.5 $\mu\text{g}/\text{m}^3$).

Risk-Based Screening Criteria

In cases where appropriate standards do not exist, risk-based screening criteria have been developed for residential (including the non-WTC site workers) receptors. (In the absence of OSHA standards, it is beyond the scope of EPA's mission to develop "occupational" screening values.) The risk assessment paradigm detailed in EPA's "Hazard Evaluation Handbook: A Guide to Removal Actions" (HEH) was employed for this initiative (except where otherwise noted in the Table 1 footnotes). Screening levels reflect the most current toxicity criteria (Slope Factors and RfCs) on EPA's IRIS database.

For carcinogenic compounds excess lifetime cancer risk was set at E-04 (one-in-ten thousand). The residential exposure scenario in the HEH was modified for carcinogens from the default of 30 years (upper-bound estimate for residency in one dwelling) to 1 year (to reflect an upper bound estimate for the length of time a resident may be potentially exposed to WTC-related

contaminants). In cases where the screening value based on a noncancer endpoint is more stringent, screening values for both cancer and noncancer endpoints are presented. It is also noted that the default 30 year exposure duration (and the 1 year site-specific adjustment) reflects an apportionment between child (20% of total exposure duration) and adult (80 % of total exposure duration) receptors. Because children have comparatively greater (as a function of body weight) respiration rates than adults, the screening values presented in Table 1 are marginally more stringent than values that would otherwise be derived by direct application of IRIS verified Unit Risk values.

For noncarcinogenic compounds, the Hazard Quotient (chronic daily intake/RfC) was set at 10. A Hazard Quotient of 10 is employed in the HEH to account for the fact that chronic toxicity criteria (RfDs/RfCs) are being applied to sub-chronic exposure scenarios that are not expected to exceed 6 months - 1 year in duration. Accordingly, a Hazard Quotient of 10 was utilized for non-carcinogens in Table 1 to reflect a similar (i.e., upper bound of 1 year) exposure duration. It is noted that contaminants (both non-carcinogens and carcinogens, alike) can exhibit acute effects from short-term, high-dose exposures. Because the screening values in Table 1 are based on subchronic exposure (i.e., 1 year), acute effects from exposures that are below the screening levels would be unlikely. Additionally, a review of California EPA's (CAL-EPA) Acute Risk Levels demonstrates that the screening criteria in Table 1 are categorically more stringent than the Cal-EPA's analogous acute levels.

NOTE: Individual sampling results that exceed screening values should not be interpreted to represent the occurrence of an adverse health effect. Rather, such information indicates the need for careful monitoring and the assessment of longer-term data trends for evaluation against appropriate health criteria. That is, most of the screening levels have been developed to account for continuous one year average exposure durations. Because these screening levels assume continuous exposure for an extended duration, the average of the measured concentrations is more appropriate for evaluating risk than an individual measurement. Consequently, miscellaneous individual values above the screening level may not necessarily be indicative of potential for concern.

Table 1
World Trade Center Screening Criteria

Contaminant	Site Worker ⁽¹⁾	Resident ⁽²⁾
<u>Inorganics</u>		
Asbestos ⁽³⁾	.1 f/cc (PCM)	70 S/mm2 (TEM)
Cadmium	5 µg/m ³	.2 µg/m ³ ⁽⁹⁾ 3 µg/m ³ ⁽⁵⁾
Chromium ⁽⁴⁾	100 µg/m ³	.6 µg/m ³ ⁽⁵⁾
Lead	50 µg/m ³	1.5 µg/m ³ ⁽⁷⁾
Manganese	5 mg/m ³	.5 µg/m ³ ⁽⁶⁾

Contaminant	Site Worker ⁽¹⁾	Resident ⁽²⁾
Sulfur Dioxide	5 ppm	.14 ppm ⁽⁷⁾
<u>Particulates</u>		
Total	15,000 µg/m ³	NA
Respirable	5,000 µg/m ³	NA
PM _{2.5}	NA	40 µg/m ³ ⁽⁸⁾ 65 µg/m ³ ⁽⁷⁾
PM ₁₀	NA	150 µg/m ³ ^(7,8)
<u>Semivolatiles</u>		
Dioxin/Furans (TEQ)	NA	.162 ng/m ³ ⁽⁵⁾
PCBs	1,000 µg/m ³	.73 µg/m ³ ⁽⁶⁾ 9 µg/m ³ ⁽⁵⁾
PAHs ⁽¹⁶⁾	NA	6 µg/m ³ ^(5, 17)
<u>Volatiles</u>		
Acetone	1,000 ppm	1.5 ppm ⁽⁶⁾
Benzaldehyde	NA	860 ppm
Benzene	1 ppm	.02 ppm ⁽⁹⁾ .21 ppm ⁽⁵⁾
Benzonitrile	NA	NA
1,3 Butadiene	1 ppm	.01 ppm ^(5, 15)
Chloromethane	100 ppm	.4 ppm ⁽⁶⁾ 2.6 ppm ⁽⁵⁾
1,4 Dioxane	100 ppm	.5 ppm ⁽⁵⁾
Ethanol	1,000 ppm	45 ppm ⁽¹⁰⁾
Ethylbenzene	100 ppm	2.5 ppm ⁽⁶⁾
Freon 22	1,000 ppm ⁽¹⁴⁾	140 ppm
Propylene	LEL ⁽¹³⁾	simple asphyxiant
Styrene	100 ppm	2.3 ppm ⁽⁶⁾
alpha methylstyrene	100 ppm	.1 ppm ⁽⁶⁾

Contaminant	Site Worker ⁽¹⁾	Resident ⁽²⁾
Tetrahydrofuran	200 ppm	.9 ppm ⁽⁵⁾
Toluene	200 ppm	1.1 ppm ⁽⁶⁾
Xylenes	100 ppm	1 ppm ⁽¹¹⁾
<u>Reactive Gases</u>		
Acetaldehyde	200 ppm	.05 ppm ⁽⁶⁾ 1.3 ppm ⁽⁵⁾
Formaldehyde	.75 ppm	.04 ppm ⁽¹²⁾ .35 ppm ⁽⁵⁾
Acrolein	.1 ppm	.0001 ppm ⁽⁶⁾

Units

f/cc = fibers (>5 µm length) per cubic centimeter of air

S/mm2 = structures (>.5 µm length) per square millimeter of filter paper

ppm = parts per million in air

µg/m³ = micrograms of contaminant per cubic meter of air

ng/m³ = nanograms of contaminant per cubic meter of air

NA - Not Applicable

Footnotes:

1. "Site Workers" refers to all workers involved in the response/demolition of the World Trade Center. Listed values are Occupational Safety and Health Administration (OSHA) Permissible Exposure Limits (PELs), Time Weighted Averages (TWA) unless otherwise noted.

2. "Residents" refers to people living in the vicinity of the World Trade Center as well as all other potentially exposed workers not involved in the response/demolition

3. Resident screening value is based on Asbestos Hazard Emergency Response Act (AHERA) methodology which uses transmission electron microscopy (TEM), and because of its basis in "background" (vs a risk basis) includes all asbestos fibers greater than 0.5 microns in length. Worker values are based on phase contrast microscopy (PCM, - which doesn't distinguish asbestos from other fibers) or, for results above the PCM screening value, TEM to derive a PCM equivalence that includes all asbestos fibers greater than 5 microns in length.

4. Screening values for chromium were based on the most toxic form (hexavalent)

5. EPA - Hazard Evaluation Handbook (HEH) (carcinogen) > 1 year of continuous exposure equating to an excess lifetime cancer risk of one-in ten thousand

6. EPA - HEH (noncarcinogen) > Hazard Quotient (HQ) = 10
7. National Ambient Air Quality Standard (NAAQS)
 - Lead is a 3 month average
 - PM_{2.5} is a 24 hour average
 - Sulfur Dioxide is a 24 hour average primary standard
8. Air Quality Index (AQI)
9. Non cancer effects based on CAL-EPA toxicity studies
10. American Conference of Governmental Industrial Hygienists (ACGIH) Threshold Limit Value (TLV)
11. Agency for Toxic Substances and Disease Registry (ATSDR) Inhalation minimum risk level (MRL) x 10
12. ATSDR acute MRL
13. Lower Explosive Limit (2 - 11 %)
14. National Institute of Occupational Safety and Health (NIOSH)
15. Proposed Reference Concentration (RfC) - HEH (noncancer) > Hazard Quotient (HQ) = 10
16. Based on Benzo(a)pyrene toxicity equivalency factor toxicity equivalency factor (TEF)
17. EPA National Center for Environmental Assessment (NCEA) provisional inhalation Slope Factor (3.1 E 00 mg/kg/day⁻¹)

APPENDIX B - TABLE OF MONITORING LOCATIONS

Table 1. Overview of monitoring locations and responsible parties (see note at end of table for specific notes).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
I. EPA's Environmental Response Team Lettered Sites				
Location A	Barclay St & West Broadway	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	
		Particulates, VOCs	24 hr. sample daily; grab (VOC)	EPA/ORD
Location B	Church St and Dey St	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	
Location C	Liberty St and Trinity St	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	
		Particulates, VOCs	24 hr. sample daily; grab (VOC)	EPA/ORD
Location C1 (note: station C and C1 are "alternate" stations; see footnote 1)	Broadway and Liberty St	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	
		Particulates	24 hr. sample every 3rd day	EPA/ORD
Location D	Albany St & Greenwich St	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	
Location E	Liberty St & South End Ave	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
I. EPA's Environmental Response Team Lettered Sites (cont'd).				
Location F	Vesey St & West St	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, Metals	8 hour sample twice per week	
Location G	Church & Duane St	Asbestos	2 - 12 hour samples daily	Contract
Location H	Chase Manhattan Plaza	Asbestos	2 - 12 hour samples daily	Contract
Location I	Broadway & Wall St	Asbestos	2 - 12 hour samples daily	Contract
Location J	Warren & West St	Asbestos	2 - 12 hour samples daily	Contract
Location K	Albany & West St	Asbestos	2 - 12 hour samples daily	Contract
		Particulates, VOCs	24 hr. sample daily; grab (VOC)	ORD
		Metals, Silica	8 hour sample twice per week	Contract
Location L	North Side of Stuyvesant High	Total particulates	~ 8 hours/day	Onsite Dataram
		Asbestos	2 - 12 hour samples daily	Contract
		Metals, Silica	8 hour sample twice per week	Contract
Location M	Harrison St & West St	Total particulates	~ 8 hours/day	Onsite Dataram
		Asbestos	2 - 12 hour samples daily	Contract
Location N	Pier 25, Southside	Total particulates	~ 8 hours/day	Onsite Dataram
		Asbestos	2 - 12 hour samples daily	Contract
Location P	Albany St & South End Ave	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs Metals, Silica	8 hour sample twice per week	
Location Q	Barclay St & West St	Asbestos	2 - 12 hour samples daily	Contract
Location R	EPA Taga Bus	Total particulates	~ 8 hours/day	Onsite Dataram
		Dioxins (2)/PCBs, PAHs Metals, Silica	8 hour sample twice per week	Contract

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
I. EPA's Environmental Response Team Lettered Sites (cont'd).				
Location S	Rector Pl & South End Ave	Asbestos	2 - 12 hour samples daily	Contract
		Dioxins (2)/PCBs, PAHs Metals, Silica	8 hour sample twice per week	
Location T	Pier 6 Heliport	Asbestos	2 - 12 hour samples daily	Contract
Location U	Pier 6, Exit 2	Asbestos	2 - 12 hour samples daily	Contract
Location V	Pier 6, Bus Sign	Asbestos	2 - 12 hour samples daily	Contract
Location W	Wash Tent, West Street & Murray	Asbestos	2 - 12 hour samples daily	Contract
WTC - Building 5 SW	AKA, Location 3A	Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	Contract
WTC - Church & Vesey (alternate for WTC; see footnote 1)	AKA, Location 3B	Dioxins (2)/PCBs, PAHs, Metals, Silica	8 hour sample twice per week	Contract
S.I. Landfill Sites	17 Landfill Sites + 3 offsite locations	Asbestos	1 - 12 hour sample daily	Contract
	5 Landfill Sites	Total particulates	12 hour sample daily when temp. & humidity specs are met.	Onsite Dataram
	2 Landfill Sites + 3 Offsite Locations	Metals	1 - 12 hour sample weekly	Contract

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
II. Extended Monitoring Network- NYSDEC Numbered Air Monitoring Stations				
1	Park Row & Spruce Street, NY, NY	Asbestos	12 hour sample daily	Contract
		Dioxin (1)	72 hour sample every 3 days	Region 7
		VOC's	24 hr. sample every 3rd day	ORD
		Aldehydes	24 hr. sample every 3rd day	NYSDOH
		PM Speciation	24 hr. sample every 3rd day	Contract
		PM Sizing	continuous-by NYSDEC	Climet
		PM10, PM2.5	continuous- by NYSDEC	PM 2.5 TEOM/ PM10 Filter
2	Chambers St.& West St., NY, NY	Asbestos	12 hour sample daily	Contract
		Dioxin (1)	72 hour sample every 3 days	Region 7
		VOC's	24 hr. sample every 3rd day	ORD
		Aldehydes	24 hr. sample every 3rd day	NYSDOH
		PM Speciation	24 hr. sample every 3rd day	Contract
		PM Sizing	continuous-by NYSDEC	Climet
		PM10,PM2.5,PM	continuous- by NYSDEC	PM 2.5 TEOM/ PM10 Filter
3	U.S. Coast Guard, 1 South Street, NY, NY (Battery Pk)	Asbestos	12 hour sample daily	Contract
		PM10, PM2.5	continuous- by NYSDEC	PM 2.5 / PM10 Filter

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
II. Extended Monitoring Network- NYSDEC Numbered Air Monitoring Stations (cont'd)				
4	Canal Street Post Office, 350 Canal Street, NY NY	Asbestos	12 hour sample daily	Contract
		PM10, PM2.5	24 hour sample daily-by NYSDEC	PM 2.5 / PM10 Filter
5	PS 154, 333 East 35th Street, Bronx, NY 10454	PM2.5	continuous-by NYSDEC	PM 2.5 TEOM
		Asbestos	12 hour sample daily	Contract
6	IS 143, 511 West 182nd Street NY, NY 10033	PM2.5	continuous-by NYSDEC	PM 2.5 TEOM
		Asbestos	12 hour sample daily	Contract
7	PS 274, 800 Bushwick Ave, Brooklyn, NY 11221	PM2.5	continuous-by NYSDEC	PM 2.5 TEOM / PM10 Filter
		Asbestos	12 hour sample daily	Contract
8	PS 44, 80 Maple Parkway, Staten Island, NY 10303	PM2.5	continuous-by NYSDEC	PM 2.5 TEOM
		Asbestos	12 hour sample daily	Contract
9	PS 199, 39-20 48th Ave, Long Island City, NY 11104	PM2.5	continuous-by NYSDEC	PM 2.5 TEOM
		Asbestos	12 hour sample daily	Contract

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
III. Extended Monitoring Network- NJDEP Air Monitoring Stations				
NJ-Shell	West Avenue, Sewaren, NJ	Asbestos	1 - 12 hour sample on Mon. and Thurs.	Contract
NJ-Citgo	Tremly Point Road, Linden, NJ	Asbestos	1 - 12 hour sample on Mon. and Thurs.	Contract
NJ-FMC	Roosevelt Blvd., Cartaret, NJ	Asbestos	1 - 12 hour sample on Mon. and Thurs.	Contract
NJ-Liberty	Liberty State Park, @ WTC Disaster Family Center	Asbestos	1 - 12 hour sample on Mon. and Thurs.	Contract
IV. Extended Monitoring Network- EPA/ORD Numbered Air Monitoring Stations				
14	Albany & West St NY, NY	Dioxin (1)	72 hour sample every 3rd days	Region 7
		PM Speciation	24 hr. sample every 3rd day	Contract
		PM Sizing	continuous-by NYSDEC	Climet
		PM10, PM2.5	continuous-by NYSDEC	PM 2.5 TEOM/ PM10 Filter
		VOCs	24 hr sample every 3rd day	ORD
15	23 Wall Street, NY, NY	PM10, PM2.5	continuous-by NYSDEC	PM 2.5 TEOM/ PM10 Filter
		Aldehydes	24 hr. sample every 3rd day	NYSDOH

Table 1. Overview of monitoring locations and responsible parties (cont'd).

Site Name	Site Location	Pollutants Measured	Sampling Frequency	Analytical Laboratory
IV. Extended Monitoring Network- EPA/ORD Numbered Air Monitoring Stations (cont'd)				
16	290 Broadway NY, NY	PAHs & SVOCs	12 & 23 hour samples	ORD
		Particulates	continuous	ORD

Notes for Table.

Column 1: Site Name

- Though not "lettered", the WTC - Building 5 SW site and the Staten Island Landfill Sites have been run by EPA's Environmental Response Team and are included here.
- The New Jersey Department of Environmental Protection (NJDEP) site names were designated by NJDEP
- Locations C (Liberty & Trinity) and C1 (Liberty and Broadway), and 3 (WTC Building 5) and 3A (Church & Vesey) were "alternate" pairs of stations, meaning that sample dates alternated between the paired sites.
- 290 Broadway was a sample site that measured several contaminants, but only on 1 date, October 10, 2001. Because there was only one date of sampling, this site is not listed above.

Column 2: Site Location:

Column 3: Pollutants Measured:

- Dioxin (1) = 72-hr samples collected by EPA Department of Environmental Science and Assessment (DESA) Region 2 personnel and analyzed by Region 7.
- Dioxin (2) = 8-hr samples collected by EPA Emergency and Remedial Response Division (ERRD) Region 2 personnel and analyzed by a contract laboratory.

Column 4: Analytical Laboratories:

- Contract = Laboratories contracted by EPA to conduct analysis.
- ORD = Human Exposure and Atmospheric Sciences Division (HEAS) in the National Exposure Research Laboratory (NERL), in Research Triangle Park, North Carolina.
- Region 7 = Regional Laboratory Branch, in the Environmental Services Division (ESD) in Region 7, Kansas City, Kansas.